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Design and development of in-wheel motor-based walking assistance system

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Abstract

The purpose of this study is to develop a walking assistance system with mobility support and life support functions so that the elderly with reduced physical ability and patients who are uncomfortable when moving can move comfortably indoors and outdoors, and help social life. An obstacle recognition sensor module that can be applied indoors and outdoors is installed on a lightweight walking aid. The purpose of this study is to develop a walking assistance system with mobility support and life support functions so that the elderly with reduced physical ability and patients who are uncomfortable when moving can move comfortably indoors and outdoors, and help social life. An obstacle recognition sensor module that can be applied indoors and outdoors is installed on a lightweight walking aid. It is a system structure of an integrated actuator and brake system that can avoid obstacles in consideration of the safety of the elderly and is easy to install on the device. In this paper, the design of a lightweight walking aid was designed to increase the convenience of the socially disadvantaged and the elderly with reduced exercise ability. In addition, in order to overcome the disadvantage of being inconvenient to use indoors due to the noise and vibration of the motor during operation, an In-Wheel type motor is applied to develop and apply a low noise, low vibration and high efficiency drive system.

Keywords: *In-Wheel Motor, Walking assistance system, Socially disadvantaged, aging society*

1. INTRODUCTION

Currently, our society is foretelling an aging society as human lifespan has been extended due to the development of medicine and improvement of living environment. After passing through an aging society, Korea is expected to enter a super-aged society after 2026, and explosive demand from the silver industry is expected to improve the quality of life of the elderly [1-3]. Therefore, there is a demand for the development of a future-type mobile device for overcoming obstacles that can overcome decreased lower extremity muscle strength and decreased motor nerves caused by aging.

Looking at overseas trends on walking aids is being conducted abroad, but only a passive type of walking aid is currently on the market, and there is no development of a mobile device for walking assistance in Korea.

In the welfare field, research is being conducted to overcome various types of disabilities and the elderly by combining robot technology and IT technology. The development of assistive devices for rehabilitation is emerging as a core technology.

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Therefore, this thesis aims to develop a lightweight walking aid that can be moved indoors and outdoors, supports daily life, and can be easily moved by vehicle. The universal design technology that allows sitting/standing motions regardless of the user's characteristics is applied. In addition, since it is used in an indoor environment, an in-wheel motor is installed in the driving device to reduce noise and vibration.

2. DESIGN OF THE PROPOSED MODEL

In order to design the design of a lightweight walking aid to increase the convenience of the socially disadvantaged and the elderly with reduced mobility, this study is based on the universal design principle so that it can be used by various elderly people, patients in need of rehabilitation, and the disabled. It was designed as shown in Figure 1 to satisfy both stable and highly mobile electric walking aids and wheelchairs. As another function, it is designed to be light, convenient, and adjustable according to the will of the user.

Figure 1. Concept Design

Looking at the design details for each part of the lightweight walking aid, Fig 2 shows the design of the handlebar, which is designed in a structure that can drive left and right motors using a pressure sensor for directionality.

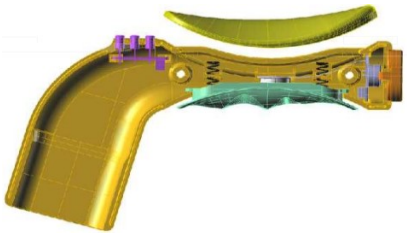
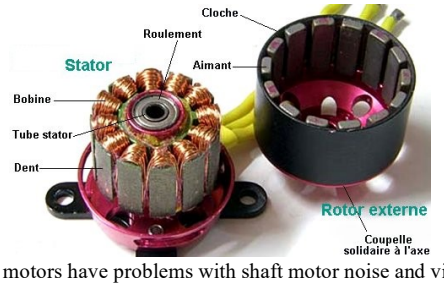


Figure 2. The design inside the handlebar with pressure sensor and motor drive

Figure 3 presents a new design of the in wheel outer rotor method to solve the noise of the motor shaft and the vibration problem when driving on a curved road.



Existing motors have problems with shaft motor noise and vibration.

As an alternative to the problem, the use of an in-wheel outer rotor type motor.

Figure 3. Adopted In Wheel Outer Rotor method

This is the motor type with the Adopted In Wheel Outer Rotor (IWOR) [4-5]method in Fig. 3. It is a system that independently drives the In Wheel Outer Rotor (IWOR) by installing a drive motor inside the wheel mounted on the wheel of the electric scooter [6]. Since all wheels are individually controlled, stability is good when cornering and there is no energy wastage in the process of power transmission, so fuel economy It has the advantage of having a large improvement effect.

By using the IWOR, it is possible to eliminate powertrain components such as the engine and to control the driving force of each wheel, and because it independently controls the driving force of each wheel in a manner similar to torque vectoring, environmental performance, safety, and convenience as shown in Fig. 4, it is possible to improve the vehicle speed, reduce the body weight, solve the problem of power loss, which is a disadvantage of electric vehicles, and secure additional interior space.

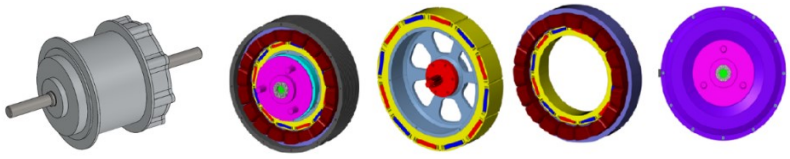


Figure 4. Design of Outer Rotor Motor ASSY

3. INTEGRAL ACTUATOR AND BRAKE SYSTEM DESIGN

Figure 5 shows the modules and sensors applied to the development of lightweight walking aids that are easy to move indoors and outdoors and support daily life and move by vehicle. It is a system structure of an integrated actuator and brake system that can avoid obstacles in consideration of the safety of the elderly and is easy to install on the device.

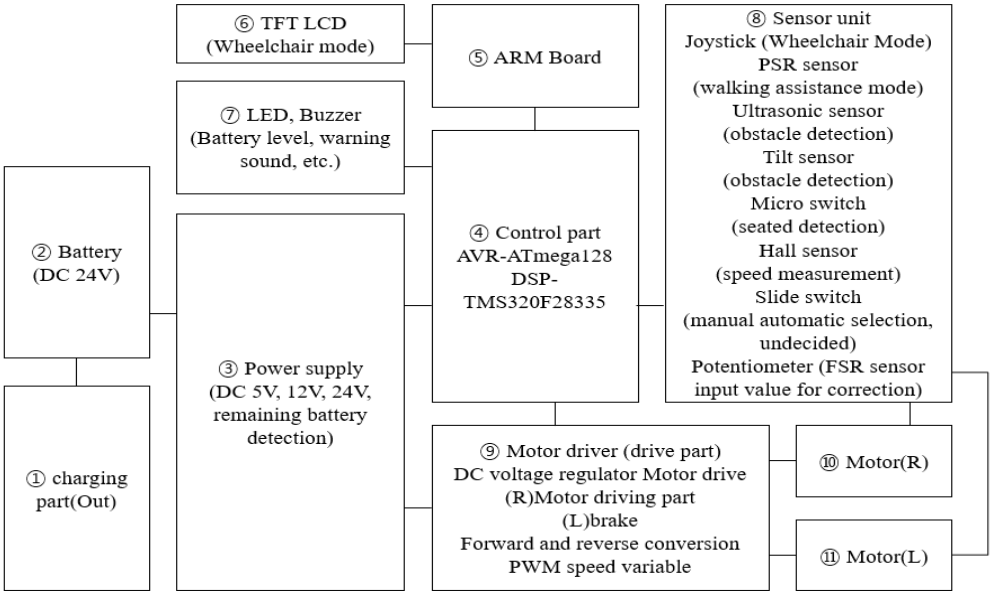


Figure 5. Process of integral actuator and brake system

① Charging part: 24V charger for lithium polymo capable of rapid charging is used, and 24V lithium polymer charger, DC Jack, etc. are used as main parts. ② Battery: A 24V lithium polymer battery is used, and the capacity is more than 10Ah. It is decided by considering the continuous operation time and the amount of

current consumption per hour. 24V lithium polymer, connector, etc. are used as main parts. ③ Power supply: Designed to stably supply DC 5V required to drive CPU and 24V DC required to drive motor. Main components: LM2576-5V (Regulator), rectifying capacitor, coil, diode, etc. are used. ④ Control unit: Controls sensor input processing, display, and motor driving. AVR-ATmega128, DSP-TMS320F28335, 16MHz X-tal, KA75420, 74LV245/SO are used as main parts. ⑤ ARM Board: In charge of TFT LCD display. ⑥ TFT LCD: A color TFT LCD is installed to control the operation of the equipment in wheelchair mode. ⑦ LED, Buzzer: The remaining battery capacity, manual and automatic mode, etc. are displayed using LED to make it easy for users to check, and a buzzer is used to output a warning sound.

⑧ Sensor unit: Various sensors are used so that the user can use the equipment conveniently and safely, and when using the wheelchair mode, the user can control the speed and direction by manipulating the joystick.

FSR sensor (walking assistance mode): When using the walking assistance mode, it detects the user's force, allowing the user to control the desired speed and direction. Sensors used in the system include ultrasonic sensor (obstacle detection), tilt sensor (equipment tilt detection), and micro switch (locked seating): When using wheelchair mode, it detects whether the user is normally seated in the seat and blocks malfunctions in advance. Hall sensor (speed measurement): Measure the speed of the motor and check whether it operates normally. Slide switch (automatic/manual mode selection): When automatic mode is selected, power is supplied to enable automatic walking assistance mode and wheelchair mode, and when manual mode is selected, power supply is cut off to prevent battery consumption and enable manual operation do. ⑨ FDP047AN08A0, TC4420, FQA70N10, SB2045FCT, S50D50C, etc. are used as the motor driver (drive part), and the DC voltage regulator controls the strength of the voltage supplied to the motor drive part.

Figure 6 shows the application of the In-Wheel type motor to overcome the noise and vibration of the motor when using a lightweight walking aid in this paper.

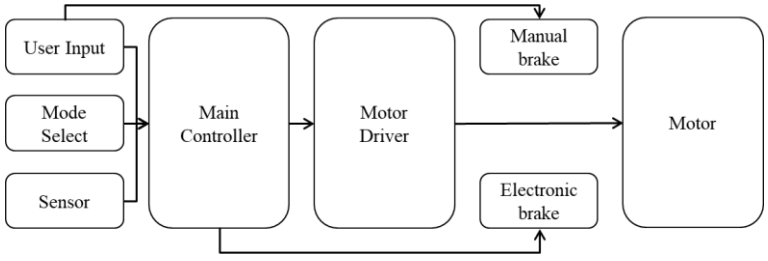


Figure 6. Picture of used in-wheel motor

Figure 7 shows the design and application of the in-wheel motor. The figure on the left shows the design of the in-wheel motor, and the figure on the right shows the actual application.

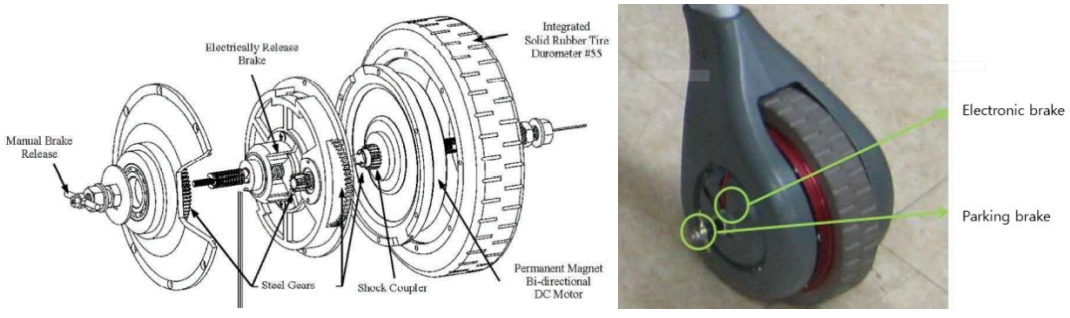


Figure 7. Picture of used in-wheel motor

4. RESULT

Figure 8 is a graph measuring the In-Wheel type motor driving power according to the development of lightweight walking aids. The driving voltage control test is a voltage and current test according to Buck Data when the motor is no load.

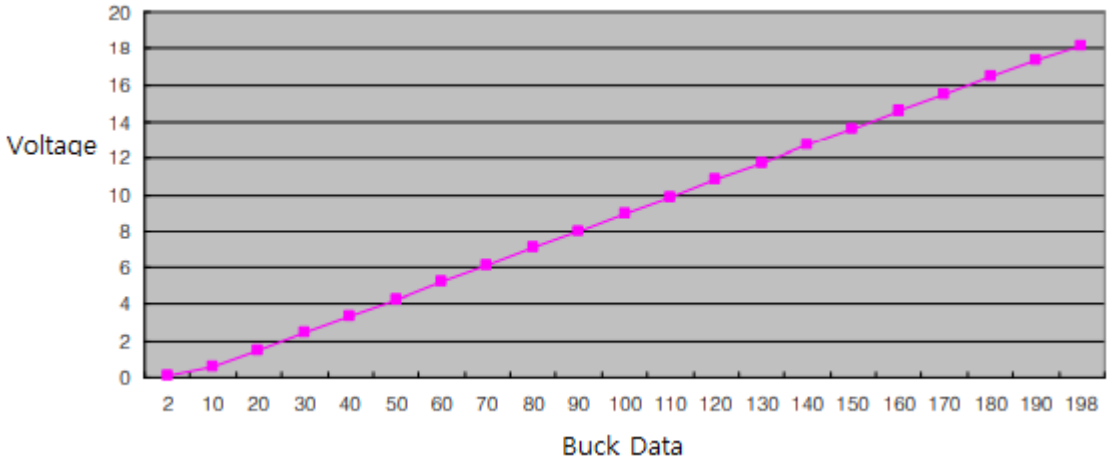


Figure 8. Voltage and current test according to Buck PWM Data when there is no motor load

Figure 9 shows the result of the final model presented in this paper, and the low-noise, low-vibration, and high-efficiency drive system was developed and applied by applying the in-wheel type motor to make it convenient to use indoors due to the noise and vibration of the motor when used.

Figure 9. The final concept product of the proposed 3-stage folding electric kickboard

5. CONCLUSION

In an aging society, the silver industry is rapidly increasing, and technology development of rehabilitation assistive devices is emerging as a key to overcome “various disabilities and the elderly with disabilities” by combining robot technology and IT technology.

In this study, a walking assistance system with mobility support and life support functions was developed so that the elderly with reduced physical ability and patients with mobility difficulties can move indoors and outdoors conveniently and help social life. We designed and developed a lightweight walking aid to support movement and daily life indoors and outdoors, and to be able to move by vehicle an avoidance algorithm was designed.

An obstacle recognition sensor module that can be applied indoors and outdoors is installed on a lightweight walking aid. It is a system structure of an integrated actuator and brake system that can avoid obstacles in consideration of the safety of the elderly and is easy to install on the device.

In addition, in order to increase the convenience of the socially disadvantaged and the elderly, a light and lightweight walking aid was designed as much as possible. In addition, a low-noise, low-vibration and high-efficiency drive system was developed and applied by applying an In-Wheel type motor to make it convenient to use indoors due to the noise and vibration of the motor during use.

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